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3 Mexican crops of agroalimentary importance

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Abstract

In the world, 12 countries are considered with a vast diversity, they are harboring 60-70% of the total biodiversity from the planet. Brazil, Colombia, Indonesia and México occupied the first positions in the list. In México, 47500 plant species are recognized to now, several of these species are used by the people in different regions of the country. Mainly of the uses are regarding to religious ceremonies, medicinal and agriculture, but the potential use of these plants is not been established yet. Unfortunately, there is few information regarding these alternative crops, the objective of these paper is to analyze some of these ancient cultures, their history and traditional uses and biotechnological potential.

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Introduction

Mexico is ranking number four in the countries with the higher biological diversity in the world. With 65 000 species registered, the country is harboring 10 % from the genetics resources of the world. México is the center of origin of several crops, such as corn, chili pepper, cacao, avocado, tomato, peanut, and beans. Traditionally just few plants had been recognized from México, in fact, some of these plants had been focus in the agriculture programs in the country, because the income for its commercialization is very attractive.

In the other hand, there are several plants associated to the Mexican culture since the pre-hispanic times; they are used by the population with different traditional applications that include alimentary, medicinal, ornamental and agricultural among others. With the arrive of the biotechnology, another perspective could be added to these crops, increasing their value (agronomical, nutrimental, or medicinal) and the possibility for the exploiting in a economical way, carrying benefits to the population that use to grow these plants.

I. Emergent crops with biotechnological potential

Nopal (*Opuntia* spp)

History and common uses

The utilization of the cactus *Opuntia* spp. by man is registered in México from prehispanic times; they played a major role in the agricultural economy of the Aztec empire. With maize (*Zea mays*), amaranth (*Amaranthus hypochondriacus*) and agave (*Agave* spp.), opuntias (*Opuntia* spp.) are the oldest cultivated plants in México **[1]**. The semiarid regions of the central part of México host the greatest genetic diversity of prickly pear cactus (young cladodes) in the world, as well as the greatest cultivated area **[2]**. Cacti to produce nopalitos can grow in poor and infertile soil of semiarid zones, where no other plants can grow, contributing to the food security of populations in agricultural poor areas. Their production and consumption is not restricted to mexican territory now; actually this crop is popular in few other countries due to its attractive taste, nutritional quality and effects on human health **[3]**. People eat its young stems cladodes as vegetable in a variety or recipes. Its succulent fruits (prickly pears) are appreciated for their sour taste in savoury dishes. Fully grown cladodes are also useful as animal forage **[4, 5]**.

Nutrimental content and medical uses

The nutritional value of nopalitos is considered to be intermediate between lettuce and spinach **[6]**. Also, these materials are good source of β-carotene (provitamin A) and ascorbic acid (vitamin C), two important vitamins known that significantly reduce the risk of certain types of cancer, as well as cardio-vascular and chronic degenerative diseases associated with ageing **[7, 8, 9]**. They contain sugars, protein and lipids; minerals including calcium, potassium and magnesium **[3, 5, 10]**. Cladodes consumption can improve glucose control and modulate renal water and sodium handling in type 2 diabetes patients. Their dietary fiber content has the capacity to absorb large amounts of water, forming viscous or gelatinous colloids that help to absorb organic molecules. They can control high blood pressure and also reduce triglycerides and total and low density cholesterol levels **[11, 12, 13]**. Although traditionally used as a valuable health supporting nutrient, the vegetative parts of the *Opuntia* spp. plants have been scarcely studied as food in human nutrition and modern health.

Opuntia fruits (prickly pear)

The prickly pear is the fruit of the genus *Opuntia*, which belongs to the Cactaceae family. It is a berry, consisting of a thick pericarp with a number of small prickles, the fruits could be reddish purple, yellow or white in color, with a sweet pulp intermixed with a number of small seeds **[13, 14]**. On the basis of fruit development and ripening, there are prickly pears of early, intermediate, and late ripening **[2]**, depending on the time required for full fruit development from anthesis to physiological maturity. Fruit ripening includes changes that enhance visual appearance, flavor and textural changes that favor consumption. In most fruits, all of the major cell wall polysaccharides appear to be modified during the softening that occurs in the course of ripening **[15]**. Cell wall disassembly is likely to result, at least in part, from the action of enzyme-mediated hydrolysis of cell wall components **[6, 16]**.

The fruits have been found to contain 12-15% sugars (mostly glucose), 0.6% protein, and 0.1% lipids; minerals include calcium, potassium, and magnesium (490, 2200, and 850 ppm db, respectively). Prickly pear is thus an interesting food; its pulp is rich in glucose, fructose and pectin and its peel contains cellulose, calcium and potassium. Its use as human food fortifies the nutritional contribution in the arid and semi-arid zones where it is cultivated **[14]**.

Biotechnological approach

The cactus family comprises more than 1500 species, the plants consists of green succulent stems, leaves are often absent, an important feature of the stems is the presence of areoles, which produce spines, lateral shoots and flowers **[5]**. Taking advantage of this property, some protocols for tissue culture regeneration have been established, and open the chances for the development of a gene transfer method that could help in the breeding of this specie **[5]**.

Some of the restrictions for the commercialization of the stems (cladodes) and fruits (tunas) are the presence of spines, the abundant number of seeds and the pectin production. No success exists in the identification of genes related to these properties, although some spineless materials had been recovered.

Opuntia spp., known as prickly pear, are the most widely cultivated cactus crops, the main cultivated cactus pear is *Opuntia ficus-indica*, which includes several cultivars with different characteristics as size, color, spines or seeds **[7]**. The main interest is the use of molecular markers for the classification of materials in the germplasm collections, the right use of these markers will help in the breeding programs already established.

Studies on prickly pears in molecular biology are scarce, at best; the first reports for the isolation of genes are those related to ethylene production, it will help to design strategies for the control of fruit ripening and to extend shelf life, or to enhance fruit quality.

A big challenge not related to nopal quality but with the nutrimental content, is to enhance of nutrimental properties. One example could be the increase of the content of vitamin A, trough the expression of enzymes of the carotenoid pathway in cladodes, like in the golden rice, where the expression of these genes increased the content in β-carotene. Other choices could be the increase in protein content with genes from other sources, or the increase of ascorbic or citric acid, increasing the antioxidant properties.

Marigold (*Tagetes erecta*)

Common uses

Marigold (*Tagetes erecta*), belongs to the Magnoliopsidae class (Angiospermae), and to the Asteraceae (Compositae) family. It is an annual plant, with colorful flowers (yellow to orange), due to the carotenoids, mainly lutein **[17]**. The origin of the *Tagetes erecta* specie is México, this plant is cultivated in Veracruz, State of México, Tabasco, Chiapas, Hidalgo, Guanajuato and Sinaloa **[18]**. This plant had been grown since the prehispanic times, mainly for religious ceremonies related to the death, and is called “flor de muerto”**[19]**.

Marigold (*Tagetes erecta*) has been used as an ornamental plant and in traditional Mexican medicine. Marigold is commercially cultivated and flower extracts are used as poultry feed supplements for the coloring of egg yolks **[20]**. The principal pigment of its flowers is lutein, a fat-soluble carotenoid. This plant also contains bioactive compounds that are widely employed as insecticides, fungicides and nematicides.

Carotenoid pigments in plants fulfill essential functions in photosynthesis, carrying out key roles in photosynthetic reaction centers. Their biosynthetic pathway provides intermediates for the biosynthesis of the plant growth regulator abscisic acid and they are precursors of vitamin A for human and animal diets **[21, 22]**. They have been linked to some health benefits such as prevention of cancer and cardiovascular diseases **[23, 24, 25, 26, 27, 28, 29]**.

Pigment production

The carotenoid biosynthetic pathway **[30]** takes place within the plastids; the first committed step is the condensation of two geranylgeranyl diphosphate (GGDP) molecules to produce phytoene, catalyzed by the enzyme phytoene synthase (PSY). Two enzymes, phytoene desaturase (PDS) and ξ-carotene desaturase (ZDS), introduce four double bonds that convert phytoene to lycopene, the first coloring carotenoid, via phytofluene, ξ-carotene and neurosporene. Then, lycopene may undergo cyclization by two different cyclases. One branch leads to β-carotene (β,β-carotene) and its derivative xanthophylls zeaxanthin, violaxanthin and neoxanthin **[30]**. The alternative branch leads to carotenoids with one β and one ε ring, such as α-carotene and lutein; the latter is a major xanthophyll in the light harvesting system of higher plants **[31]**.

Carotenoid formation is a highly regulated process; the concentration and composition of leaf xanthophylls are affected by light intensity **[32]**, and the accumulation of specific carotenoids in chromoplasts of fruits and flowers is developmentally regulated **[33]**.

Biotechnological potential

With the growing of legislative restrictions on the use of synthetic colors, a re-consideration of the natural plant pigments as colorant of foods is taking place. With the production of new colorants the market must be open. Although marigold flower extract has been used, the potential use of marigold as a natural food colorant has not been exploited. The manipulation of carotenoids pathway may help to produce a variety of natural pigments, those can be exploit as food colorants over the artificial pigments.

The yield of marigold flowers depends in several factors, including cultivar and horticulture practices. The yield shows great variations in number and flower weight, from 12 to 30 ton/hectare. A practical approach could be the expression of genes related to flower determination (i e. *apetala 1*) in order to normalize the flower production in the different areas. In citrus, the expression of this gene results in plants with precocious flowering and fruiting

The nematocidal effect of marigold is attributed to the presence of tiophenes, which are natural occurring biocides. From fresh ground roots several bithienyls, besides tertienyl were recover. Some terpenoids and other class of compounds with larvicidal activity and actives against various organisms were found in plant extracts. The final identification of the pathway of synthesis of these compounds may help in the isolation of genes, that could be expressed in other sensitive plants to these microorganisms.

II. Ancient Mexican plants with biotechnological potential

Chilcuague (*Heliopsis longipes*)

Origin and common uses

Heliopsis longipes, which common name is "chilcuague", is a Mexican herbaceous plant which is found in a mountainous area where the states of San Luis Potosí, Guanajuato and Querétaro meet. Prehispanic Mexicans employed the extracts from the root system of this plant to heal diverse pains such as toothache, earache and headache, **[34]**, it was recognized for its pungent taste and for causing numbing and salivation. Three centuries latter, in 1948, Elbert L. Little Jr. published a small description of *Heliopsis longipes* and suggests the potential use of the plant as an insecticidal **[35]**. Despite its importance the use of chilcuague roots was marginal and restricted to the communities of the localities where the plant grows, one of the main reasons for this phenomena is the fact that the massive propagation of the plant has experienced problems, mainly in transplanting after seedling stage.

Biomedical and biotechnological potential

Alkamides are secondary metabolites comprising over 200 related compounds widely distributed in plants, they have been found in 10 plant families: Aristolochiaceae, Asteraceae, Brassicaceae, Convolvulaceae, Euphorbiaceae, Menispermaceae, Piperaceae, Poaceae, Rutaceae, and Solanaceae. The Asteraceae, Piperaceae, and Rutaceae families comprise the diverse species that contain high levels of alkamides **[36, 37, 38]**. The general structure of alkamides originates from the condensation of an unsaturated fatty acid and an amine **[39]**. Although different chain length alkamides have been found in plants, most of them contain a 2*E* double bond conjugated to the amide group substituted with a *N*-isobutyl group **[40]**.

Recently, it has been shown that alkamides are the main compounds found in *Heliopsis longipes* roots and are responsible for diverse biological effects on bacteria, insects, plants and humans **[41, 42]**. The main alkamides isolated from chilquague roots are *N*-isobutyl-2*E*,6*Z*,8*E*-decatrienamide (afinin), *N*-isobutyl- 2*E*-decenamide, and *N*-isobutyl-decanamide. The biological effects of afinin on diverse organisms have been tested:

i) The effect of ethanolic extract from *Heliopsis* roots and purified afinin was tested on grubs of *Aedes aegypti*, the vector for Dengue transmission. Both, the extract and pure afinin showed a high toxic effect on the insect grubs, demonstrating that the molecule responsible for this lethality is afinin. Despite the exciting role of afinin on *Aedes aegypti* mortality, further studies most be performed in order to know the specific target of afinin (Molina-Torres & Ramírez-Chávez, unpublished data).

ii) Afinin and afinin-derived molecules display a negative activity against mycelial growth of diverse phytopathogenic fungi, such as *Phytphthora infestans, Fusarium spp., Sclerotium rolfsii* and *Verticillium spp.* Also negative effect on cell growth and division of *Escherichia coli* and *Bacillus subtilis* was shown (Molina-Torres & Ramírez-Chávez, unpublished data).

iii) Ramírez-Chávez and co-workers also investigated the effects of affinin, and its derivates, *N*-isobutyl-2*E*-decenamide and *N*-isobutyl-decanamide, on plant growth and early root development in *Arabidopsis thaliana*. They found that treatments with affinin in the range of 7x 10^{-6} – 2.8 x 10^{-5} M, enhanced primary root growth and root hair elongation; whereas higher concentrations inhibited primary root growth that related to a reduction in cell proliferating activity and cell elongation. Also, *N*-isobutyl-2*E*-decenamide and *N*-isobutyldecanamide were found to stimulate root hair elongation at concentrations between 10^{-8} to 10^{-7} M **[42]**. Similar results have been obtained using potato, tobacco and rice, as experimental models (Molina-Torres & Ramírez-Chávez, unpublished data). Taken together these results point to alkamides as a new group of plant growth promoting substances and open the possibility of using them as molecules for improved plant production. Besides several new and more detailed analyses of the effects of afinin on the diverse experimental models, previously described studies point out "Chilcuague" as one of the Mexican plants with higher biomedical and biotechnological potential.

Agave species: Not only tequila

History and common uses

First Europeans in arrive to America discovered the original plants of the new world known as "metl" in the Nahua culture, and they named them with the antillan word "maguey". In the middle of the XVIII century, Carl von Linné renamed them as *agave*, this word is the grecolatin voice for "admirable", the Swedish naturalist was right, agaves are not only admirable, but diverse and amazing in several aspects. In México there are at least 136 species and 26 subspecies. For several Mexican prehispanic cultures agaves represented a valuable crop. The general uses that Mesoamerican cultures gave to the different agave species include: i) the manufacture of clothes and utensils with fibers from leaves of *A. fourcroydes*, *A.sisalana* (henequen), *A. lechuguilla*

V. Torr. and *A. salmiana*, ii) the elaboration of the sacred alcoholic beverage "pulque" or "octli" using the juice of *Agave salmiana* and *A. atrovirens* are valued for pulque production.

Is our intention to remark the biotechnological potential of two particular agave species, *A. salmiana* and *A. atrovirens*. These two species of agave represented a major crop for prehispanic and modern cultures, also known as "Maguey pulquero" or "mountain maguey", these species are original from Central México and show marked differences with other members of the agave genera.

In his botanical book, Ximénez (1615) describes with interest "the plant called Metl… in particular the specie that produce leaves such as those of aloe but a lot bigger and thicker, because sometimes, they reach the length of a middle-size three" in reference to plants from *A. salmiana and/or A. atrovirens.* Ximenez gives a complete description of the plant adaptation " … and it grows in any kind of soil, although better in cold lands, cause it is subject to the inclemency of the sky, even if there´s dryness it does not get withered, and seems that is one of the most abundant things in this New Spain", and of the uses that native mexicans gave to it, "…and seems that only with this plant would be enough to provide all the things that are necessary for human life, cause the whole plant has an utility for building, the leaves are used as roofing tiles, the stems are used as beams… and also from the leaves, the people extract fibers and they make canvas shoes and cloths… with the tips they make nails and needles… and cutting the stalk of the plant with a knife they perform a cavity from which a juice called *aguamiel* emanates during several days…. From this juice they make *pulque*, alcohol, honey, sugar, vinegar…" among others.

"Pulque", which is an ancient alcoholic beverage made by the natural fermentation of the sap from this agave, played a central role in religious life of mexican prehispanic cultures, mainly the Mexica and the Tolteca, where pulque was considered as sacred. After the arrival of Spanish conquerors and till the Mexican revolution, pulque was considered the national beverage and its production was one of the most rentable businesses in the country. However, beer displace pulque in consume of modern Mexicans, and with the loss of interest in pulque the benefits around this Mexican crop became fairly poor. In present days several poor communities preserve the culture of this agave because of the several benefits it represents to the people. Besides pulque, honey and vinegar consume, which has become a rich source of food for farmers, the symbiotic interactions that these plants establish with diverse insect and animal species represent an ecological niche from which mexican farmers, as old mexicans did, obtain not only high amounts of proteins for their diets, but also materials from the sub-products of the plants for building and clothing. Not only the juice has a impact on human and animal nutrition, the cuticle and leaves from both, *A. atrovirens* and *A. salmiana*, have in present days an important culinary use extended in many towns of central Mexico. Also, agave as forage has a recent development; fresh *pencas* (leaves) are used desert regions to feed cattle.

Biotechnological potential

In recent times, scientists had turned their eyes to the study of these agaves since diverse perspectives. Studies over the plant compounds demonstrated that *A. salmiana* produces high levels of several terpenes such as, Phellandrene, Terpinene, p-Cimene, Limonene, Naphtalene, Linalool, 4-Terpineol, *trans*-Nerolidol and Geraniol. Contains high levels of saponins. The alchohol obtained from the fermentation and distillation of *A. salmiana* is called Mezcal. The volatile compounds present in Mezcal have been identified, confirming the presence of terpenes and other molecules **[43]**.

Some studies have been focused on the nutritional values of pulque and the fermentation that gives rise to it. Morales de León and co-workers **[44],** showed that pulque amino acid content is interesting since its protein is high in tryptophan (2.35 g/16gN) and sulphur amino acids (2.72 g/16gN) although it is limiting in lysine (0.39 g/16gN).

Also, the bacterial diversity in pulque has been studied by sequencing 16S rDNA from clone libraries obtained from three pulque samples **[45]**. In those studies *Lactobacillus acidophilus*, *Lactobacillus* strain ASF360, *L. kefir, L. acetotolerans, L. hilgardii, L. plantarum, Leuconostoc pseudomesenteroides, Microbacterium arborescens, Flavobacterium johnsoniae, Acetobacter pomorium, Gluconobacter oxydans,* and *Hafnia alvei*, were detected in *pulque*. Identity of 16S rDNA sequenced clones showed that bacterial diversity present among *pulque* samples is dominated by *Lactobacillus* species (80.97%).

The size of adult plants from both species, which may be the biggest non-forest plants in Mexico, and its capacity to produce big amounts of sap, have point to the idea of using them as biological reactors. Genetic transformation for *A. tequilana* is underway, this technical approach opens the possibility to transform this big agaves with transgenes of interest, not only to improve the nutritional content of sap and pulque, but also to obtain a gene product in big amounts by simply cutting the stalk of the plant. Nevertheless, this is just an exciting idea which needs careful designing and several experiments to become real.

Peyote (*Lophophora williamsii*)

Historical approach and common uses

Peyote is a cactus original from Chihuahua desert; it grows from central México till the North of Texas as a wild plant. This plant has provoked controversy since the arrival of the first Europeans in the New World. Spanish conquerors coffered the adjective of “satanic" to its effects on human behaviour, nevertheless peyote continues to playing a major sacramental role among the Indians of Mexico. Chronicler Fray Bernardino de Sahagún (1499-1590), described Peyote uses among the Chichimeca, in “El codice florentino”: "There is another herb like tunas (*Opuntia spp*.) of the earth. It is called Peiotl. It is white, is found in the North Country. Those who eat or drink it; see visions either frightful or laughable. This intoxication lasts two or three days and then ceases. It is a common food of the Chichimeca, for it sustains them and gives them courage to fight and not feel fear or hunger or thirst. And they say that it protects them from all danger." **[46]**.

Sahagún estimated that Peyote was known to the Chichimeca and Tolteca at least 1890 years before the arrival of the Spanish conquerors. However, very recent radiocarbon and alkaloid analysis of two archaeological specimens of peyote strengthens the evidence that native North Americans recognized the psychotropic properties of peyote as long as 5700 years ago.

Dr Francisco Hernández the physician sent by King Philip II of Spain to study Aztec medicine was the first in describing the plant in his ethnobotanical study of New Spain: "The root is of nearly medium size, sending forth no branches or leaves above the ground, but with a certain woolliness adhering to it on account of which it could not aptly be figured by me. Both men and women are said to be harmed by it. It appears to be of a sweetish taste and moderately hot. Ground up and applied to painful joints, it is said to give relief. Wonderful properties are attributed to this root, if any faith can be given to what is commonly said among them on this point. It causes those devouring it to be able to foresee and to predict things…."

Medical potential

Native Mexicans used peyote as a ceremonial plant related to its psychotropical effects nevertheless there are registered about its use as analgesic, against toothache, asthma and cold. Active substances present in peyote are mainly alkaloids such as Mescalin, Anhalodin, Peyotlin, Lofoforin, Hordenin, N-Methyl-mescalin, N-Acetylmescalin, Anhalinin, Anhalamin, and Tiramina.

In present days, peyote compounds are considered as Psychedelic substances with a potential use in psichoterapy **[47, 48]**. Also, Peyote extracts have been associated with stimulating the central nervous system and regulating blood pressure, sleep, hunger and thirst. Franco-Molina and coworkers **[49]** evaluate the effects of peyote methanolic extracts on some parameters of mouse and human leukocyte immuno competence and tumour cell growth. Peyote extracts activated nitric oxide production by murine macrophages, and stimulated proliferation of murine thymic lymphocytes. In addition, peyote extract induced up to 1.85-, 2.29- and 1.89-fold increases in mRNA signal of IL-1, IL-6 and IL-8 by human leukocytes. Peyote extracts were toxic for murine lymphoma L5178Y-R and fibroblastoma L929, and human myeloid U937 and mammary gland MCF7 tumour cell growth; peyote extract caused 1.3%, 8%, 45% and 60% viability respectively **[49]**. Despite the important results obtained by diverse groups, further and detailed approaches are necessary to understand and make use of the *Lophophora williamsii* biomedical and biotechnological potentials.

Mezquite, carob tree (*Prosopis juliflora*)

History and common uses

"The *Mizquitl* is a very common tree en the New Spain, it grows spontaneously everywhere… is a wild and thorny tree, has subtle leaves similar to those of the birds… has some cases similar to those of tamarinds, which are good to eat, cause they are long and sweet and tasty and chichimeca Indians make of them *tamales*… and the tree produces the real arabic rubber… infusions of the plant applied to the eyes cures indispositions, cooked crusts cures pains in the first childbirth, skin dying…" This is the description that Ximénez **[34]**, gives about the *Mezquite*, a tree original from México, which is a characteristic element of the arid zones in the North of America, also it has been extended to central and south America, Asia and Africa.

In México *Prosopis juliflora* is found mainly in semi-desert regions from Baja California and Chihuahua in the north, to Oaxaca and Veracruz in the south. Native Mexicans used the products and subproducts of the tree as a source of food medicine and wood. They use fresh and dry cases to eat them or as forage and, as previously described by Ximénez, the flour obtained form the cases was used to prepare the "Mezquitamales" and the "mezquiatol" and mixed with water they obtained an alchoholic beverage similar to beer **[50, 51]**.

In present days the sub-products of the tree represent important sources of diverse products. In examples the exudates, which is similar to Arabic rubber is used as an adhesive, also is used as an adulterant in food industry for candy and bitumen production. The chemical composition of the rubber has been analyzed and it contains metoxiglucuronic acid, galactose and arabinose. Fruits and seeds are rich in protein (60%), sucrose (13 to 36%) and carbohydrates (45 to 55%). This composition makes rubber and fruits of *Mezquite* important for human and animal feeding **[52, 53]**.

The rubber is also used in pharmaceutical industry as agglutinant and to prepare weaves in the textile industry. The tree is used in paper industry as a source of pulp. The crust posses tannins in 6 a 7 % and is used to tan skins **[50]**.

An enormous potential

Several recent sudies found the utility of Prosopis-derived compounds in diverse fields. At the ecological level this plant has been proposed as a tool to solve soil contamination, analysis of soil and plant samples (root and shoot) of *Prosopis juliflora* collected in the vicinity of metal based foundry units and assessed for their heavy metal content showed that Copper (Cu) and Cadmium (Cd)contents were much higher in plant components compared to their extractable level in the soil. Considering the accumulation efficiency and tolerance to Cd and Cu, this plant can be explored further for the decontamination of metal polluted soils **[54, 55]**.

An attempt to identify α-amylase and trypsin-like proteinase inhibitors was carried out in *Prosopis juliflora*, showing the presence of both in dry seeds. Furthermore, a novel trypsin inhibitor, with molecular mass of 13,292 Da, was purified showing remarkable in vitro activity against pests *T. castaneum* and *C. maculates* which are capable of decreasing crop production causing severe economical losses **[56]**.

Also, compounds with biological activities have been identified in *P. juliflora* and its properties have been characterized. Alkaloids isolated from the extract of mezquite leaves have shown to inhibit plant growth. The chemical structures of three alkaloids were established by ESI-MS. The concentration required for 50% inhibition of control for root growth of cress (*Lepidium sativum L.*) seedlings was 400 microM for 3-oxo-juliprosopine, 500 microM for secojuliprosopinal, and 100 microM for a (1:1) mixture of 3-oxo-juliprosine and 3'-oxo-juliprosine, respectively **[57]**.

A very remarkable finding is that the alkaloid juliflorine from *Prosopis juliflora* inhibits acetylcholinesterase and butyrylcholinesterase enzymes in a concentration-dependent fashion, these enzymes are involved in Alzheimer. The cholinesterase inhibitory potential along with calcium-channel blocking activity of the compound could make it a possible drug candidate for Alzheimer's disease **[58]**.

Antidiabetic properties of prosopis gum alone and as a bioadhesive base for the delivery of metformin have been suggested. The bioadhesive value of the gum was commensurate with those of Carbopol 974-P and sodium carboxymethyl cellulose (NaCMC). The release of the drug was higher from prosopis gum based bioadhesive formulations than from NaCMC and Carbopol 974-P products. The gum showed moderate antidiabetic properties when used alone. In combination with metformin in a bioadhesive form, the glucose lowering effect was found to be synergistic **[59]**.

Huitlacoche or cuitlacoche

History and uses

Huitlacoche or cuitlacoche are ethnic name given to the edible and young fruiting bodies (galls growing on the maize ears) of the Basidiomycete fungi

Ustilago maydis **[60]**. It also called, corn mushroom, maize mushroom, Mexican truffle, and corn smut. It is a costly and much-coveted corn fungus or parasite that occasionally balloons on sweet corn causing kernels swell to 10 times their normal size during the rainy season, mainly **[61]**.

Huitlacoche is distributed throughout the world. It is generally accepted that *Ustilago maydis* is native of the western hemisphere and was carried to Europe by the early Spanish explorers **[62]**. In Mexico those are human consumed since prehispanic times. The Aztecs are said to have prized huitlacoche and the Hopi Indians thought it a delicacy. The black spores were referred to as "excrement of the gods". The cause of corn smut, the fungus *Ustilago maydis* was recognized in 1883 by Brefeld, he inoculated maize plants spraying a suspension of sporidia into the whorls of maize and he observed that *U. maydis* could be propagated indefinitely on nutrient substances.

Nutrimental content

During long time corn smut have been studing, sometimes farmers had tried to eliminate the fungus from maize fields, at the end of the nineteenth century, were publicated losses due to corn smut in different semipopular publications **[63]**, but farmers founded out the economical potential due it´s exquisite flavor. *U. maydis* has the ability to produce B-vitamins, as riboflavin, niacin and folic acids, with the exception of vitamin B12. Huitlacoche offers a very attractive chemical composition and desirable nutritional attributes, it is a good source of protein (10-25%); free aminoacids, it has also high content of lysine, fiber (10-14%) carbohydrates, essential fatty acids have been found in this edible fungi too **[64]**, and represents a good model to found compounds with nutraceutical properties as other edible mushroom such as *Lentinus edodes*, *Pleorotus spp* and *Volvariella volvacea*.

Problematic

In the last decades plant breeders have attempted to develop resistant maize cultivars rather than to select susceptible lines that would be useful to huitlacoche, but the increase in huitlacoche's demand in México and other countries had caused that it had to do with accomplishing his production to industrial scale **[62]**. One of the most studied aspects to produce huitlacoche in industrial scale have been the inoculation technique. In this way, farmers and researchers have been trying distinct inoculation methods for *U. maydis,* such as dusting spores, spraying spores, injecting spores and partial vacuum **[62]**. In the early of the past century, some researchers concluded that applications of large amounts of inoculum in water did not increase the severity of smut by injury to young, rapidly growing plants did. Introducing sporidia or teliospores into plant wounds created by sand-blasting did not increase smut incidence in recent field trials **[65]**. Christensen **[66]** noted that spraying sporidia or teliospores into leaf whorls or on seed did not increase the incidence of galls, but injecting sporidial suspensions into whorls of seedlings often caused leaf galls and other physiological disorder **[63]**. Ear galls are induced effectively by injecting sporidial suspensions into silk channels or ears soon after silks emerge, incidence of ear galls was nearly 97% in field trials in Georgia when 3 mL 3 mL of compatible sporidia at a concentration of 10^6 cells/mL was injected in ears when silks had emerged 5 to 10 cm **[63]**. Injection of sporidial suspensions through husk leaves as soon as silks were visible was a reliable method used in a greenhouse study to produce stigma infections from which ear galls formed when kernels were allowed to mature **[60, 65]**.

Biotechnological approach

Is complex to understand the potential if we are not able for consider the relationship between the pathogen and the plant. For that reason the principal approach to now, is the search of corn materials that could be infected with *Ustilago maydis* strains in controlled conditions as greenhouse.

Another consideration is the enhancement of the nutrimental value of cuitlacoche, the main idea is the increase in the content of aminoacids, proteins or carbohydrates. Even the development of suspension cultures of *Ustilago maydis*, in order to produce compounds (proteins, polysaccharides) with anticancerigen activity.

Concluding remarks

The crops that we describe in this paper correspond to species associated to the culture in our country in different ways (religion, medicinal and nutrimental). The importance of each crop was described, and we shown the huge potential in all of them. They will help as a source of genes or as a live reactor that could produce compounds with industrial, medical or nutrimental importance. Although little is known about the biochemistry and physiology of most of the crops that we described, it is often possible to predict what kind of gene could help to confer a desirable characteristic.

To now, main of the research in these species is the identification of wild related materials with specific characteristics. The correct exploiting of these materials will bring important benefits, and they will result as an alternative for the development of transgenic and non-transgenic products in the developing countries.

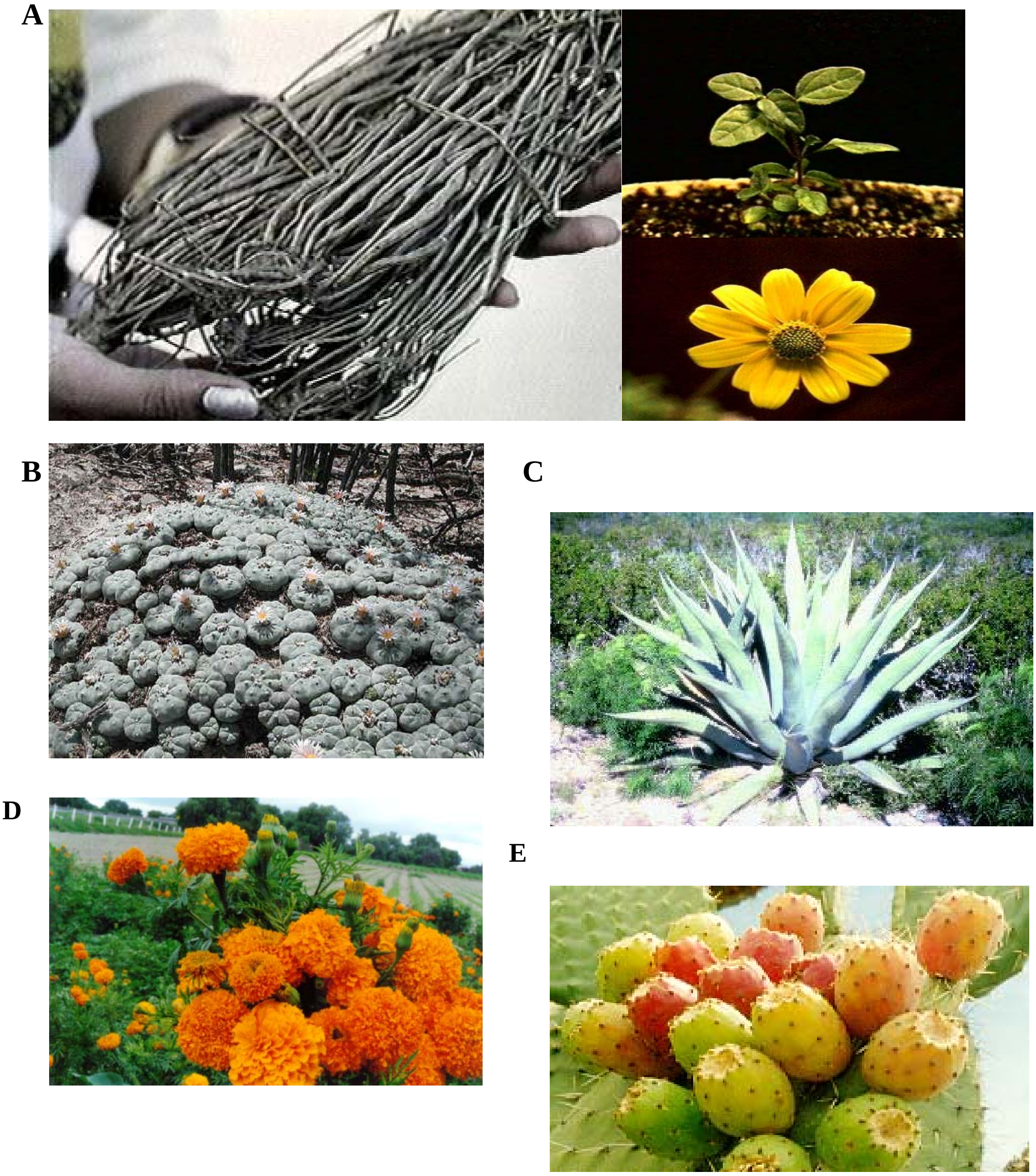

Figure 1. Emergent and ancient mexican crops with biotechnological potential. A. Chilcuague (*Heliopsis longipes*), B. Peyote (*Lophophora williamsii)*, C. Agave, D. Marigold (*Tagetes erecta*), E. Prickly pear (*Opuntia ficus indica*).

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